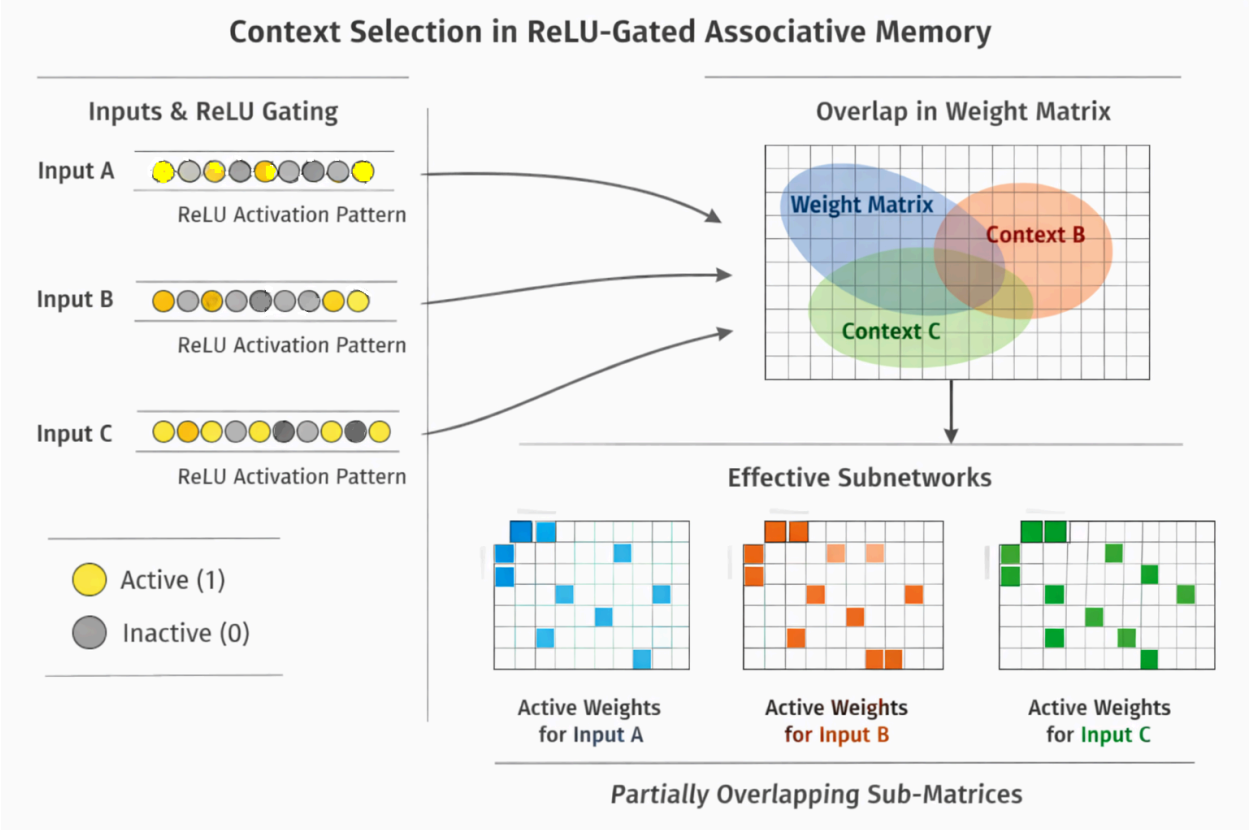

If you view a weight matrix as linear associative memory and ReLU as a gate that either blocks data or allows it through then ReLU functions followed by a weight matrix is gated linear associative memory. You could say the gates select context (like a type of key.) If statistically about 50% of the ReLU functions are letting data through to corresponding weights in the weight matrix for a particular input what can be said about context selection and the effect of that context selection on the associative memory behavior of the weight matrix?

If you treat a weight matrix as a linear associative memory and ReLU as a binary gate, then each input induces a *subnetwork*—a masked version of the full matrix. From that perspective, "~50% of ReLUs active" has some clear implications:

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1. Context = a random half-subspace (on average)

If about half the ReLUs are active, then each input selects roughly half of the rows (or columns, depending on how you view it) of the weight matrix.

- The "context" is a binary mask with ~50% ones.
- Statistically, this is close to a **random projection onto a half-dimensional subspace** (assuming no strong bias in activations).

So instead of one fixed associative memory, you effectively have **many overlapping memories**, each defined by a different mask.

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2. Capacity vs. interference trade-off

With ~50% sparsity:

- **Capacity increases**:
  Different inputs likely activate different masks, so the system can store/use different associations in different contexts.
- **Interference decreases (partially)**:
  Two inputs that activate different subsets of neurons will use different portions of the matrix, reducing crosstalk.

But:

- **Overlap is still large (~50%)**
  So memories are *not independent*. There is still substantial interference.

This puts you in a **middle regime**:

- Not fully shared memory (like a dense linear layer)
- Not fully separated memory (like a mixture-of-experts with hard routing)

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3. Context acts like a soft key

You suggested “context as a key,” which is exactly right:

- The ReLU pattern is a **data-dependent key**
- The weight matrix is a **content-addressable store**

With ~50% activity:

- Keys are **high entropy** (many possible combinations)
- But also **highly overlapping**

So:

- You get **good discrimination** between inputs
- But not perfect isolation of stored associations

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4. Effective weight matrix becomes input-dependent

For a given input, the computation is equivalent to:

- A diagonal mask (from ReLU)
- Followed by the weight matrix

So the effective mapping is:

- A **different linear operator per input**
- Chosen from an exponential family of possibilities

With ~50% active units:

- The effective matrix retains **enough degrees of freedom** to be expressive
- While still being **structured and constrained**

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5. Stability and robustness

50% gating has an interesting side effect:

- It avoids extreme sparsity (which would make representations brittle)
- It avoids full density (which would cause maximal interference)

So you get:

- **Robust recall** (enough redundancy)
- **Some specialization** (via partial masking)

This is similar to operating near a “balanced regime”:

- Not too selective
- Not too entangled

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6. Geometric interpretation

Each ReLU defines a half-space. A layer of them partitions space into regions.

With ~50% active:

- Inputs tend to lie near the “center” of activation patterns
- Each region corresponds to a **locally linear associative memory**

So globally:

- The network is a **piecewise linear associative memory**
- Each piece uses a different subset (~50%) of the full memory

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7. Big picture intuition

With ~50% of ReLUs active:

- You are using **half the memory at a time**
- But *which* half depends on the input
- Different inputs share some memory and differ on the rest

So the system behaves like:

> A large associative memory that is **continuously reconfigured by context**, where each context selects a *partially overlapping sub-memory*.

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8. What would change if it weren’t 50%?

This helps sharpen the intuition:

- **Much less than 50% (very sparse)**
  → Strong context separation, low interference, but fragile / low signal
- **Much more than 50% (dense)**
  → High interference, weak context selectivity
- **Around 50%**
  → Maximum combinatorial diversity of masks, while maintaining signal strength

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Bottom line

If about half the ReLUs are active, then:

- Context selection is **high-dimensional, high-entropy, but overlapping**
- The weight matrix behaves like a **family of partially shared associative memories**

- You get a **balanced trade-off** between:
    - specialization (different contexts)
    - generalization (shared weights)